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ORIGINAL ARTICLE

Biome changes and their inferred climatic drivers in northern and eastern continental Asia at selected times since 40 cal ka BP

Fang Tian[1,2] · Xianyong Cao[1] · Anne Dallmeyer[2] · Gerrit Lohmann[3,4] · Xu Zhang[3] · Jian Ni[5] · Andrei Andreev[6,7] · Patricia M. Anderson[8] · Anatoly V. Lozhkin[9] · Elena Bezrukova[10,11] · Natalia Rudaya[7,11,12,13] · Qinghai Xu[14] · Ulrike Herzschuh[1,15,16]

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Abstract

Recent global warming is pronounced in high-latitude regions (e.g. northern Asia), and will cause the vegetation to change. Future vegetation trends (e.g. the "arctic greening") will feed back into atmospheric circulation and the global climate system. Understanding the nature and causes of past vegetation changes is important for predicting the composition and distribution of future vegetation communities. Fossil pollen records from 468 sites in northern and eastern Asia were biomised at selected times between 40 cal ka BP and today. Biomes were also simulated using a climate-driven biome model and results from the two approaches compared in order to help understand the mechanisms behind the observed vegetation changes. The consistent biome results inferred by both approaches reveal that long-term and broad-scale vegetation patterns reflect global- to hemispheric-scale climate changes. Forest biomes increase around the beginning of the late deglaciation, become more widespread during the early and middle Holocene, and decrease in the late Holocene in fringe areas of the Asian Summer Monsoon. At the southern and southwestern margins of the taiga, forest increases in the early Holocene and shows notable species succession, which may have been caused by winter warming at ca. 7 cal ka BP. At the northeastern taiga margin (central Yakutia and northeastern Siberia), shrub expansion during the last deglaciation appears to prevent the permafrost from thawing and hinders the northward expansion of evergreen needle-leaved species until ca. 7 cal ka BP. The vegetation-climate disequilibrium during the early Holocene in the taiga-tundra transition zone suggests that projected climate warming will not cause a northward expansion of evergreen needle-leaved species.

Keywords Siberia · China · Northern Asia · Model-data comparison · Pollen · Permafrost · Vegetation-climate disequilibrium

Introduction

Eastern, central, and northern Asia is covered by various biomes reflecting two major climatic gradients. Along the south-north temperature gradient, vegetation changes from tropical rainforest, to subtropical evergreen broadleaved forest, warm-temperate deciduous forest, temperate mixed conifer-deciduous broadleaved forest, boreal conifer forest (taiga), and ultimately to arctic tundra. In the mid-latitude areas, the biomes also reflect an east–west moisture gradient, changing from forest to steppe and to desert (Alpat'ev et al. 1976; Hilbig 1995; Hou 2001; Fang et al. 2005). Forest-free areas are restricted to the cold end of the temperature gradient (e.g. arctic tundra in northern Siberia where mean annual temperature is lower than −6 °C) and the arid end of the moisture gradient (e.g. steppe and desert in arid central Asia where mean annual precipitation is less than 400 and 200 mm, respectively). Hence, climate is assumed to be the dominant control of modern biomes and forest distribution at a continental scale in northern and eastern Asia (e.g. Alpat'ev et al. 1976; Fang et al. 2005; Tchebakova et al. 2009).

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✉ Fang Tian
Fang.Tian@awi.de

Extended author information available on the last page of the article

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